Roll cover considerations for modern paper machines

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ABSTRACT

Modern paper machines require many types of covered rolls for efficient operation. The function, covering materials, and manufacture are described. The manner in which roll covering technology has been improved to meet the changing conditions in the paper industry is described. Mathematical technique permitting roll cover performance to be accurately predicted for any combination of machine condition and cover characteristic is described. The theoretical predictions are compared to laboratory data and the implications of the results of varying the parameters in the mathematical technique are discussed in detail. Specific examples of case histories of paper machine rebuilds are discussed using the computer based programmes for determining the proper roll characteristics.

INTRODUCTION

Covered rolls perform an important function in the optimum operation of several sections of the modern paper machine. They accomplish this by providing a means of controlling the intensity and width of the pressure zone or pressure nip formed between pairs of rolls.

This is particularly important in the operation of the press section of the machine where nip action is critical for maximum water removal. Since it is considerably less expensive to remove water from the sheet in the presses, compared to the dryer section, efficient operation of the presses can lead to definite energy savings.

At the size press and coating units, covered rolls apply chemicals in the desired amount and, by means of nip pressure, force the chemicals to impregnate the paper web.

At the wet end of the machine resilient coverings protect rolls against corrosive attack and assist in driving the forming fabric by increasing power transmittability.

Economics of papermaking have influenced the trends for higher speeds and greater loadings in the press section. These advances in machine design have caused roll covering companies not only to develop new cover materials to withstand these conditions, but also to develop analytical methods to predict their behaviour.

The prediction of roll cover performance is based on the mathematical treatment of the hysteresis and conductivity data in the general heat transfer equation in cylindrical coordinates. The mathematics is unique in that it incorporates the hysteresis data for specific cover materials into the heat transfer equation. The hysteresis value at given temperatures are obtained from the computer data bank through regression analysis. Due to the large number of calculations required solutions are obtained on a digital computer.

Finally the above program is used in actual cases to solve problems and to determine the nip parameters, ie. to "ENGINEER NIP" solutions, for assisting papermakers to achieve the economic and product quality benefits of more efficient and effective sheet pressing.

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A. COVERED ROLLS IN THE MODERN PAPER MACHINE

CLASSIFICATION OF COVERED ROLLS

Covered rolls in the wet press may be designated as either press rolls or carrying rolls. Press rolls are the working units which apply pressure to the paper web and its supporting felt. Carrying rolls serve to convey the felt and paper web, either together or separately, through the press section.

Each type of roll is labeled to more closely describe its use or position in the press, for example first top press, pickup, bottom press. The press rolls are further classified by their construction eg. suction press, grooved roll, etc.. In other parts of the machine covered rolls are labeled according to their function viz. top size press, couch, breakerstack.

FUNCTION AND TYPES OF COVERED ROLLS

Coverings on press rolls serve to distribute the pressure in the nip over a wide area and cause the application and release of pressure to occur more gradually. Pressure distribution can be increased or decreased by varying various parameters like cover composition, cover hardness, load, speed, etc.. For example cover hardness is the resistance of the cover material to penetration and is related to the cover's modulus which is an indication of the load carrying capacity of the covering. An increase in the hardness will decrease the nip width under a given press loading and average pressure in the nip will increase. If the covering is softened the reverse will occur.

The ratio of pressure distribution and width of nip is critical in maintaining the efficiency of the modern paper machine presses. The ratio varies with the type of press and its location in the machine. Determining the proper ratio involves complicated interrelationship of the following factors

Degree of water removal
Tendency toward sheet crushing
Extent of felt life
Roll cover life

For example increasing the cover hardness will increase the nip pressure, will improve water removal but will approach crushing condition in some presses, will tend to decrease felt life and will improve roll cover life to a degree.

Rolls which directly contact the wet sheet must be covered with compositions designed to release the sheet and minimize fiber picking. Composition covers are easily machined to provide the surface configuration required for special press design, eg. grooved rolls, drilled rolls, etc..

Carrying rolls are covered primarily to protect the metal roll from corrosion and to provide a smooth surface against the felt or paper web. The covers on these rolls may be machined to provide surface grooves or raised spirals called "worms" which help to remove wrinkles from the felt or sheet.

Specific physical and chemical properties must be built into the roll cover compounds or compositions will be discussed later.

ROLL COVERING MATERIALS

Most press and carrying rolls consist of a metal body covered with a polymeric material. A polymer is a natural or synthetic material composed of long chain molecules built up by a basic unit called monomer. The polymer may be an elastomer or a plastic. Elastomers are capable of undergoing a large amount of stretching (over 200%), while plastics are more rigid and generally will stretch from 10-25%. These definitions become confusing when we realise that by combinations of ingredients, elastomeric composition can be ranged from rock hard to sponge soft.

The term "rubber" is sometimes used to designate any type of roll covering. It is not really correct and is a very general term and can lead to confusion. Now it is more meaningful to describe covering materials as elastomeric or plastic. Mostly elastomeric materials are used in roll coverings and we shall concentrate on them.

Natural Rubber
SBR
Polybutadiene
Neoprene
Nitrile
Hypalon
EPDM

Butyl
Chlorobutyl
Silicone
Polyurethane
Epoxy
Viton

Fig. 1 Basic polymers available for Roll Covering.

Fig 1 lists the basic materials used to produce roll coverings Some of them are generic names or others are trade names, depending on which is more commonly used. Each name actually refers to a group or family of raw polymers which are chemically similar. The major types of elastomers and the variations within each type possess different physical and chemical properties which provide the roll cover manufacturer with a wide selection of materials from which to fabricate roll covers.

All elastomers cannot be used by themselves but must be made into a compound also called composition, before being fabricated into products. The expertise of the roll cover manufacturer comes into play in this area. Each elastomer represents a starting point for producing a composition with a specific set of physical and chemical properties required for a particular application. This is accomplished by adding to the basic elastomer a number of chemicals which will react with it during later processing steps to bring out the required properties. A poor choice of compounding ingredients can ruin potentially good properties of the basic elatomer. It should be mentioned at this point that two covers with the same hardness can have other properties, like tensile or abrasion, which are extremely different.

Reinforcing Fillers—viz. carbon black
Processing Aids—viz. oil
Curing System—viz. sulphur, accelerators
Age Retarders
Inert Fillers—viz. clay

Fig. 2 Typical Ingredients in a Rubber Formulation

Fig. 2 shows typical ingredients that are added in various proportions to make an elastomeric compound or composition. Over 1000 ingredients are available for making a formulation. Each ingredient performs a definite function in bringing out the final properties.

Compounding ingredients are incorporatod into the basic elastomer by using a two roll open mill or an enclosed Banbury mixer.

Because of the variety of final properties which may be built into an elastomeric composition by the process of compounding just described, roll covering companies tend to sell their product under trade names. In fact, a natural rubber covering supplied by Company A may have properties quite different from a natural rubber covering supplied by Company B. For this reason the roll user must work closely with the roll covering company to make certain that the best covering is obtained for each roll application.

ROLL COVER MANUFACTURE

Roll cover manufacture consists of various processes shown in Fig. 3.

Preparation of Metal Core
Cementing of metal Surface
Application of Covering
Vulcanisation
Grinding and Crowning
Cover Drilling, Grooving, etc.
Roll Inspection

Fig. 3 Roll Cover Manufacturing Processes

The metal cores are prepared by tooling on a lathe or by other such processes. For suction rolls special proprietary procedures are needed before the covering process can begin. With bonding methods available to-day it is not necessary to turn the metal surface. Roll balancing is carried out at this point.

The prepared metal core is then coated with one or more special cements to form the bonding system between the roll covering and the metal surface. The particular cementing system depends on type of metal of core and the elastomeric roll covering. This is a very important step in roll covering.

The approved elastomeric compound, prepared as described previously, is applied to the cemented metal surface by either the sheet method or the extrusion method. At this stage all elastomeric compounds are in a plastic state and may be formed with ease. This includes the types which will be rock hard in the finished form.

The covered roll is then placed in a steam pressure autoclave—the vulcanizer, and exposed to a heating cycle which causes reaction to take place between the polymer and its ingredients. This reaction called curing or vulcanization, changes the compound from a plastic form to a strong elastic composition. The final properties of the covering are brought out by the vulcanization process and as it is a chemical reaction it must be regulated very accurately.

The vulcanized covering is then ground to the specified diameter on a precision roll grinder. The machine must be equipped with a crowning device to grind the specified crown into the roll.

Covers which have to be drilled or grooved are rough ground. The cover is drilled or grooved and then the roll covering is given a final finish ground.

The completed roll is carefully inspected and compared to the customers specifications. Rolls are inspected for Hardness, Dimensions, Crowns, etc..

ROLL COVER PROPERTIES

Of the many material properties of the cover compounds which determine successful roll operation, Hardness is the only one generally used, by roll users, as a specification and for comparing covers. This is primarily because it can be easily measured both in the roll covering factory and in the paper mill The universal use of hardness values leads many roll users to the erroneous conclusion that hardness and possibly the type of elastomer are the only considerations necessary when discussing rolls. This is not the case as can be seen by considering Fig. 4, which lists the important properties of cover materials.

Static Compression Modulus—Hardness
Tensile Strength
Dynamic Modulus
Hysteresis—Heat Buildup—Resiliency
Thermal Stability
Abrasion Resistance—Flex Fatigue—Tear Strength
Creep—Permanent Set
Heat Aging
Adhesion to Metal
Solvent and Chemical Resistance

Fig. 4 Important Properties of Roll Covering Compositions

All the properties listed are measured and studied by roll manufacturers. The majority of these properties can be measured only by destructive type laboratory tests using elaborate equipment. This explains the popularity of the Hardness property.

Fig. 4 includes both static and dynamic properties. When dealing with products exposed to cyclical loading such as tyres or covered rolls, dynamic properties must be studied under conditions of load, speed and temperature This is due to the **viscoelastic** behaviour of elastomeric materials. Instead of acting in a true elastic manner, these materials exhibit some of the viscous response of liquids, which makes their properties extremely tite, i.e. rate of speed, and temperature dependent. With increasing temperature all properties, like modulus, strength, hardness, bond integrity etc., are affected adversely.

We will concentrate only on one property of exterme importance to us—Hysteresis. Hysteresis is the energy lost in each loading—unloading cycle as a covered roll operates. Fig. 5 is a typical low strain rate representation of this phenomenon. The loading portion of the curve is ABC and unloading CDE. The area enclosed by ABCDE is the hysteresis loss or power loss during the cycle and this mechanical loss is converted to heat which manifests itself as a rise in temperature This is due to the fact that elastomeric materials are **viscoelastic and incompressible**. Under compression the material is forced to assume a different shape and does so by flowing like a liquid.

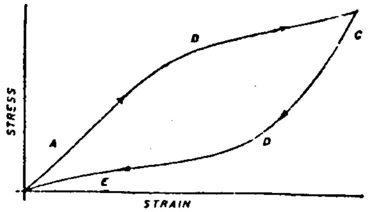


Fig. 5 Static stress versus strain with hysteresis

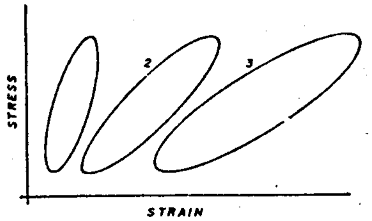


Fig. 6 Dynamic Hysteresis

At high strain rates the hysteresis cycle forms a loop. Fig. 6 shows the appearence of the cyclic hysteresis loop. The three loops are shown for a given cover compound which was subjected to a constant cyclic stress at three different temperatures. The slope of the major axis of the ellipse is the dynamic modulus of the compound at that temperature. The decrease of dynamic modulus with temperature is typical behaviour of elastomeric materials.

B. PREDICTION OF COVERED ROLL PERFORMANCE

The increased speed and loading of the press rolls leads to greater stresses in the roll cover and its bond to the metal. It also leads to a greater hysteresis loss also called power loss, which produces higher operating temperatures of the roll. The mechanical failure of the roll cover is principally a stress and temperature related phenomena.

An approximate analytical method for predicting the operating temperature distribution through the cover thickness is set forth. From experimental data and field results this analysis yields theoretical results which correlate well with the observed measurements.

Because of the large number of calculations and operations required to handle the iteration method presented, the analysis was programmed for and solutions obtained on a digital computer. Each solution needs millions of computer operations.

THEORETICAL ANALYSIS

Prediction of roll cover temperatures is the development of changing circumstances in the paper making industry. Roll cover temperature distribution is dependent on a combination of operating parameter and roll parameters. Operating parameters include press goemetry, roll speed, press loading, environmental temperature, existence of internal cooling facility etc. Roll parameters include cover composition, cover hard ness, cover thickness, roll diameter, etc.

The solution to the general one-dimensional equation governing the steady state heat transfer in a roll covering can be determined if it is possible to arrive at a power loss, i.e. hysteresis loss, distribution through the cover thickness. This power loss is a function of the stress and temperature distribution through the cover thickness. This raises the dilemma that the temperature distribution to be derived is a function of power loss which is itself function of temperature and stress.

The method used to solve this was to utilize and iteration technique whereby a starting temperature distribution is assumed from which stress and power loss distribution is determined. This allows a new temperature distribution to be generated. This process is repeated until the distributions are within some preset error limit.

HYSTERESIS AND POWER LOSS

Hysteresis is the mechanical power loss in each loading—unloading cycle and was discussed earlier in Fig. 5 and 6. For a given cover compositions the mechanical loss of power in a cycle is basically a function of the strain rate, temperature and stress of the material.

The dynamic hysteresis testing to generate data on various compositions was performed on a Satic Systems Testing Machine SF—1U. For each material composition tests were conducted and data subjected to regression analysis. Fig. 7 and 8 are typical graphs of hysteresis and dynamic modulii as a function of temperature. The data was then stored in a computer.

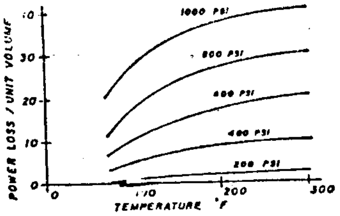


Fig. 7 Volumetric Hysteresis vs. Temperature

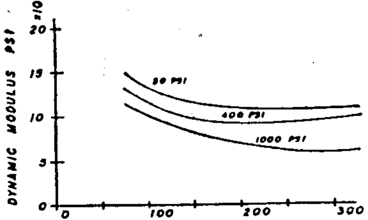


Fig. 8 Dynamic Modulus vs. Temperature

Stress Analysis

STRESS ANALYSIS

The stress distribution at the nip was studied by finite element techniques on a digital computer. An empirical equation for stress was derived and was taken as a function of the following

$$S(r) = (D_1, D_2, PLI, t, E_D, r)$$

where $S(r)$ = stress distribution as a function of radius
D_1 = diameter of roll 1
D_2 = diameter of roll 2
PLI = linearload in pounds per linear inch
t = cover thickness
E_D = Factor relating to dynamic modulus and temperature
r = radius

HEAT TRANSFER ANALYSIS

In cylindrical co-ordinates the mechanics of heat transfer is governed by

$$\frac{d^2T}{dr^2} + \frac{1}{r}\frac{dT}{dr} = -f(r)$$

where T = temperature distribution as a function of r
r = radius
$f(r)$ = internal power loss as a function of r

If Power Loss $f(r)$ is assumed to be approximate by the following

$$f(r) = a_0 r^0 + a_1 r^1 + \dots + a_4 r^4) \qquad (3)$$

then the temperature distribution will have the following general form

$$T(r) = C_1 \ln(r) + C_2 - \frac{1}{k}(a_0 r^0 + \dots a_4 r^4) \qquad (4)$$

where C_1 C_2 = arbitrary constants
k = material conductivity

This solution now reduces to a boundary value problem, where the necessary conditions are applied to equation[4]. Solutionsto this equation under various boundry conditions are well documented in Heat Transfer texts. Hence the problem is solved.

COMPARISON OF THEORETICAL AND ANALYTICAL RESULTS

Extensive heat transfer tests have been conducted on a roll test machine designed and constructed by the Research Group of Stowe Woodward Company. This test machine is shown in fig. 9.

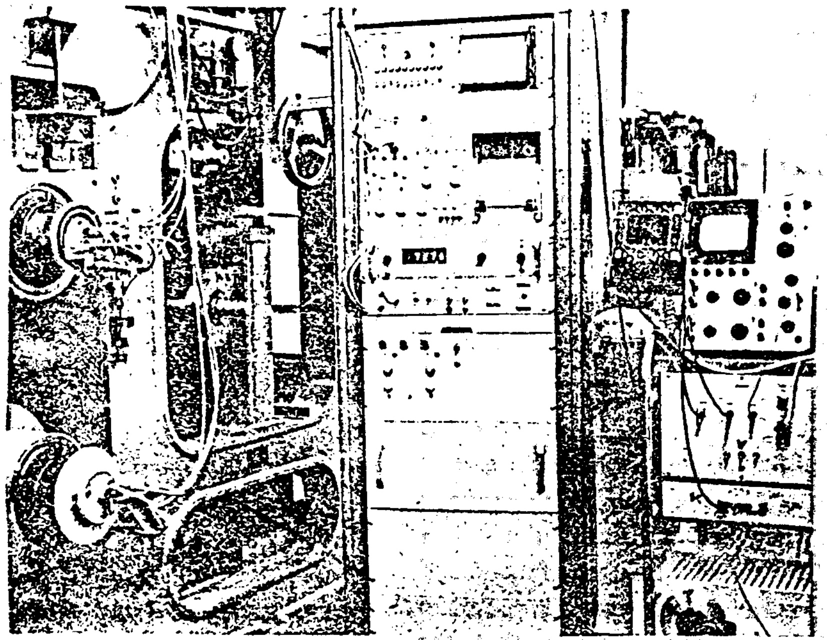


Fig. 9 Roll Test Machine

Tests were conducted on an 18 P & J standard roll cover compound at one inch thickness at various speeds and loads. Fig. 10 and 11 show sample results of this testing and compare the experimental results to that which is predicted by theory.

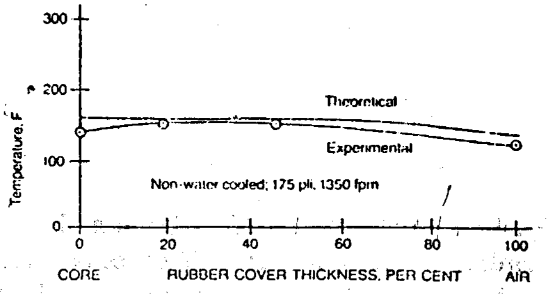


Fig. 10 Case I Experimental and Theoretical Temperature Profile

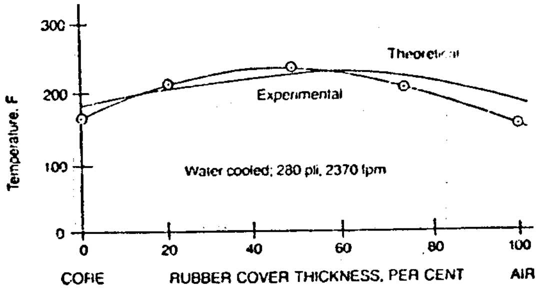


Fig.11 Case II, Experimental and Theoretical Temperature Profile

The above two figures show that the theoretical predictions are comparable to the experimental results. Fig. 10 is for a roll loaded to 30kN/m (175 pli) running at 410 mpm (1350) fpm) with no water cooling of the core. Fig. 11 is for a roll loaded to 49 kN/m (280 pli) running at 720 mpm (2370 fpm) and water cooled core.

PARAMETER ANALYSIS

When one has a system of equations to predicts heat buildup, it is informative to see the influence of various parameters that make up the equation.

Fig. 12 shows the theoretical variation of the maximum temperature in a cover as a function of cover conductivity. It can be seen that the greatest improvement occurs between conductivities of 0.00173 (0.1) and 0 00346 (0 2) W/cm deg C (BTU/ft-hr deg F).

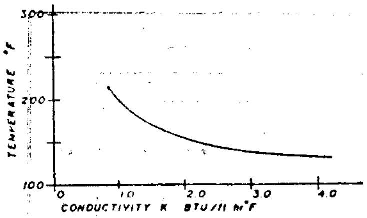


Fig. 12 Max. Roll Cover Temperature vs. Roll Conductivity

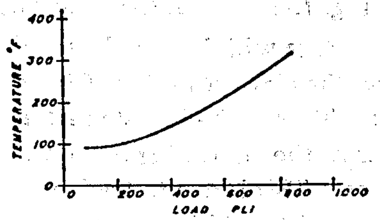


Fig. 13 Max. Roll Cover Temperature vs. Machine Load

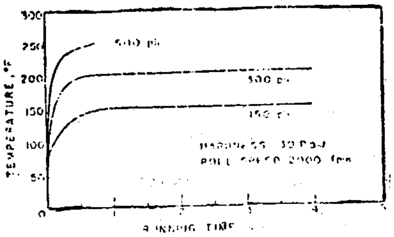


Fig. 14 Effect of increasing Load on Cover Temperature

Fig. 13 illustrates the theoretical variation in cover temperature with increased PLI loading Fig. 14 shows the measured effect of increasing load on test rolls. The obvious effect here is the increase in stress due to the higher loading. Sometimes the effect is more dramatic and occurs when a cover material is near its capacity to carry the compressive stress.

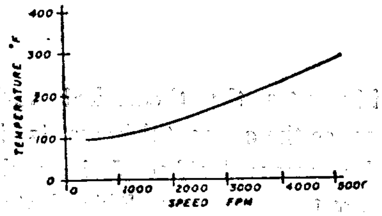


Fig. 15 Max. Roll Cover Temperature vs. Machine Speed

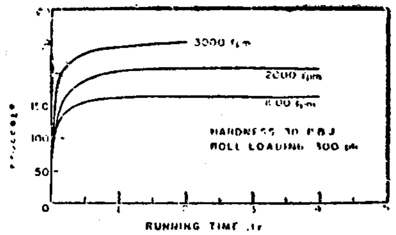


Fig. 16 Effect of increasing Speed on Cover Temperature

Fig. 15 illustrates the theoretical variation in cover temperature with increased machine speed. Fig. 16 shows the measured effect of increasing speed on test rolls. They both illustrate that as the machine speed increases the operating temperature of the cover increases. This is due to the increased number of cycles per second to which the cover is subjected.

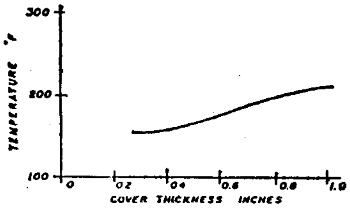


Fig. 17 Max. Roll Cover Temperature vs. Cover Thickness

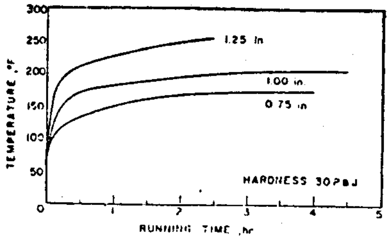


Fig. 18 Effect of increasing Cover Thickness on Heat Buildup

Fig. 17 illustrates the theoretical variation in cover temperature as the cover thickness is increased. Fig. 18 shows the measured ;effect of increasing cover thickness on cover temperature. This illustrates a fact well known to the industry that a reduction in cover thickness is accomplished by a reduction in the operating temperature of the roll.

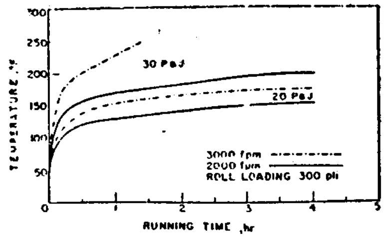


Fig. 19 Effect of Cover Hardness on Cover Temperature

Fig. 19 shows the measured effect on increasing cover hardness for a particular rubber cover composition. As expected the harder cover runs much cooler at a speed of 610 mpm (2000 fpm) the harder cover runs 22 deg. C (40 deg. F) cooler. At higher speed of 915 mpm (3000 fpm) the soft cover built up heat so fast that the test had to be discontinued.

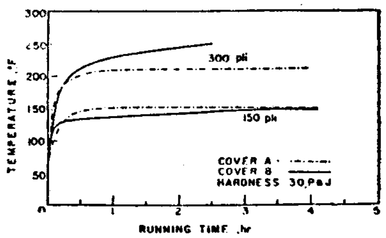


Fig. 20 Effect of Cover Compound of same Hardness on Cover Temperature

Fig. 20 shows the measured effect on load on two different cover compositions on cover temperature. Both the covers have the same hardness at room temperature, but have different properties in operation. The covers were run at 610 mpm(2000 fpm) and two loading of 26 kN/m (150 pli) and 53 kN/m (300 pli). Due to the covers having hysteresis property that are different from one another the covers show different temperature while running. At the higher load for Cover B the test have to be discontinued as the temperature rise was very high. Such tests show how important it is to study the dynamic properties of the cover compositions.

Fig. 21 shows another set of cover compounds having the same hardness, but other properties that are extremely different. This fiigure shows how the thermal stability of the Cover B results in much more uniform roll operation.

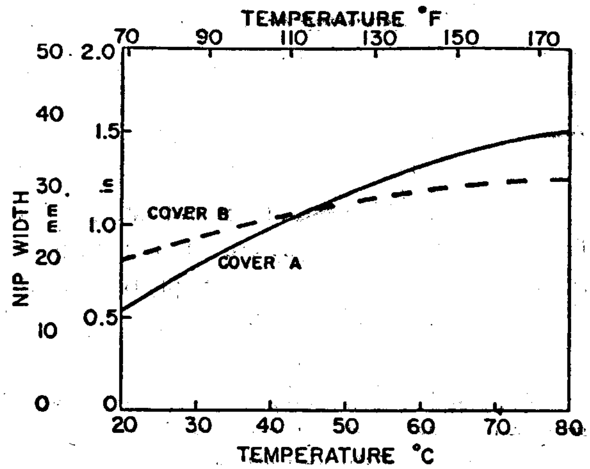


Fig. 21 Nip Width vs. Temperature for Covers of same Hardness

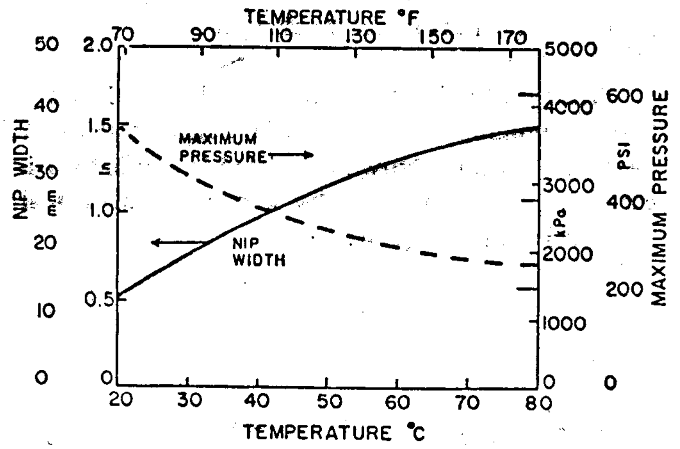


Fig. 22 Nip Properties vs. Cover Temperatures

Fig 22 illustrates what happens to nip width and nip pressure as cover temperature increases, which may be due to increased load, speed, etc. The decreasing nip pressure with increase of temperature. indicates the importance of maintaining the cover temperatures.

Fig 23 illustrates that as diameter of the role core is increased the nip pressure, at a given condition of load etc,, decreases. This decrease in pressure leads to a reduction in operating temperature of the cover. This is one of the important variables in a design of the press.

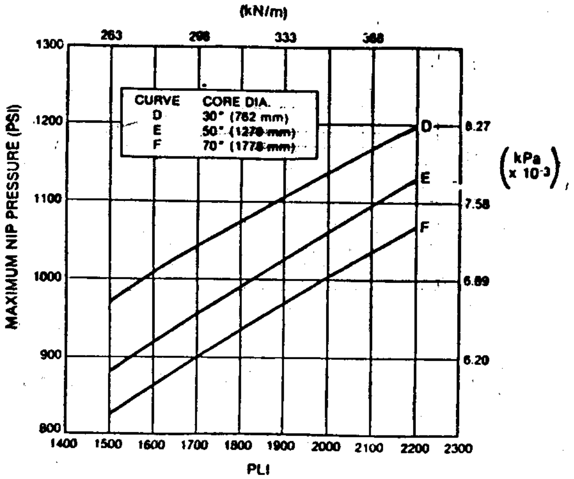


Fig. 23 Effect of Core Diameter on Max. Nip Pressure

Finally, it is important to see the effect of internal cooling of the roll cores. Fig. 24 illustrates that internal cooling is much more effective than cooling by external showers. The test was conducted on a 30 P & J roll cover 25 mm (1 inch.) thick at a speed of 1520 mpm (5000 fpm) and a load of 35 kN/m (200 pli) The roll was cooled to room temperature before conducting the next test. In Test A, no cooling medium was used and as the rise in temperature was too high for safety the test was discontinued. Test B was conducted with an external cooling shower on the roll. Test C was conducted with water circulating through the roll body. It is seen that the internal cooling is the most efficient method of cooling roll covers.

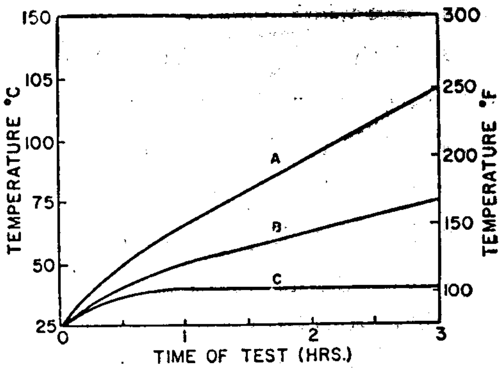


Fig. 24 Influence of Internal Water Cooling

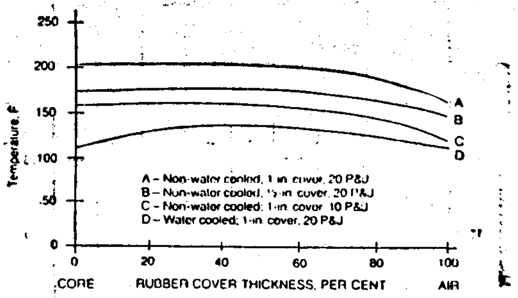


Fig. 25 Effect of Cover Thickness, Cover Hardness and Water Cooling on Cover Temperature

Fig. 25 illustrates the interaction of various factors on cover heat buildup. Curve A show that cover would have failed, whereas the same cover with water cooling would have worked as shown by Curve D. The other options like reducing cover thickness, Curve B, and increasing the cover hardness, Curve C, are also shown. The choice of the option to be used rests to with the user of the roll.

C. ENGINEERED NIPS

The above theory can be applied and used to answer the questions of the papermakers, like "How to improve the efficiency of the press ?", "How to improve the productivity of the press ?", "What happens when machine speeds or loads are increased?" The above theory and its associated computer programme can be used to bring about the best compromise between the interrelated factors like nip width, nip pressure, water removal, sheet crushing, felt life, etc.

One of the most important outputs that is obtained from this programme is the crown needed on the press rolls given the press factors like press geometry, roll constructions, press load etc.

A press role is actually a beam of circular cross section designed to carry an evenly distributed load across its face. Like any other beam under load, the press roll deflects. In order to obtain an even nip pressure across the face of the press it is necessary to compensate for the deflection. Compensating for deflection is the sole reason for crowning roll The cover composition, thickness or hardness does not affect the deflection of the roll. If the press loading is changed then the crown also must be changed.

The type of information needed and the out put from the programme are shown in Fig. 26 and Fig. 27. Please note that the crown calculated is for that particular load. This also shows the importance of crowning both the rolls in the press.

	INPUT	TOP ROLL	BOTTOM ROLL
1.	Distance between bearings (mm)	5842	5689
2.	~~Total face width (mm)~~	5080	5080
	Face width between dubs (mm)	4775	4775
3.	Outside diameter of core (mm)	915	927
4.	Inside diameter of core (mm)	254	800
5.	Core material	Granite	CI-PR40
	Modulus of elasticity (Kg/cm²)	4316×106	1406×10^{6}
6.	Press loading (Kg/cm)	89	89
7.	Weight of rolls (Kg)	9752	7529

Fig. 26 Input required for calculating the Crown required for a Press

COMPUTER PRINT OUT

CENTER LINE (mm)		N	ROLL CROWN REQUIRED CROWN (mm)		CROWN COSINE (mm)	
TOP	BOTTOM		TOP	BOTTOM	TOP	BOTTOM
0.	0.	0	1.0161	0.9944	1 0161	0.9944
238.7	238.7	1	1.0047	0.9832	1.0046	0 9832
477.5	477.5	2	0.9706	0.9498	0 9704	0.9496
716.2	716 2	3	0 9144	0 8947	0.9139	0.8943
955.0	955.0	4	0.8366	0 8185	0.8359	0 8180
1193.7	1193.7	5	0.7385	0.7223	0.7376	0.7218
1432.5	1432.5	6	0.6213	0 6076	0.6204	0 6071
1671.2	1671.2	7	0.4868	0.4759	0.4860	0.4756
1910.0	1910.0	8	0 3368	0 3292	0.3363	0.3291
2148.7	2148.7	9	0.1737	0.1697	0.1735	0.1698
2387.5	2387.5	10	0.0000	0.0000	0.0000	0.0000

The angle that minimizes the difference between the required crown and the crown cosine

For the top roll is 69 degrees

For the bottom roll is 69 degrees

Fig. 27 Output for Crown needed in a Press

For the prediction of cover performance Fig. 28 shows the type of data needed. Information needed includes the cover, cover thickness, load, speed, etc. Please note that the computer has data only on our compounds. Fig. 28 shows the information for a straight through press.

1. Roll cover material	Resistex
2. Hardness of cover (PJ)	25
3. OD (including cover) (mm)	609
4. OD of core (mm)	559
5. ID of core (mm)	457
6. OD of companion roll (mm)	482
7. Press loading (Kg/cm)	90
8. Speed (m/m)	365
9. Core material	Cast iron
10. Ambient air temp. (°C)	32.2
11. Face length (mm)	3048

Fig 28 Informatinn needed for predicting Cover Performance

Fig 29 and 30 give the typical heat transfer solution. Fig 29 gives solution considering that the role is non-water cooled. Fig. 30 shows the solution considering that the roll is water cooled. For analysis and

Maximum stress (Kg/cm^2)	33.1
Nip width (mm)	36 394
Average pressure through nip (Kg/cm^2)	24.7
Average temperature (°C)	85.0

Stress distribution through rubber cover (Kg/cm^2)

Rubber-air interface	33.2
	31.5
	29.9
	28.3
	26.9
	25.5
	24.1
	22.9
	21.6
	20.5
Rubber-material interface	19.4

	Location in mm through cover	Temperature
Rubber-air interface	25.000	71
	22.500	75
	20.000	79
	17.500	82
	15.000	85
	12.500	87
	10 000	89
	7 500	90
	5.000	91
	2.500	91
Rubber-metal interface	0	91

Fig. 29 Computer Output of Press Performance for non-water colled roll

Maximum stress (Kg/cm²)	46.9
Nip width (mm)	25.716
Average pressure through nip (Kg/cm²)	35.0
Average temperature (°C)	37.0

Stress distribution through cover (kg/cm²)

Rubber-air interface	46.9
	43.6
	40.5
	37.5
	34.8
	32.2
	29.8
	27.6
	25.5
	23.6
Rubber-metal interface	21.8

Location in mm through cover		Temperature °C
Rubber-air interface	25.000	42
	20.500	43
	20 000	43
	17.500	42
	15.000	41
	12.500	39
	10.000	37
	7.500	34
	5.000	31
	2.500	28
Rubber-metal interface	0	25

10.1 litres of 22°C fluid are required to cool external heat flux and internally generated heat.

Fig. 30 Computer output of Press Performance for water colled roll

comprehensive interpretation the output lists the maximum stress, dynamic nip width, stress distribution temperature distribution, etc.

The Engineered Nip depends upon the above predictions. It is now a matter of choosing the appropriate press design and suitable roll coverings depending upon the need for appropriate nip width, nip pressure, etc.

Using the correct combination of press and roll coverings we can give the specific pressure in the nip concerned or give the specific nip width desired. We can now increase the nip width while keeping the nip pressure the same. If the nip pressures are to high the same can be brought down without compromising on the press efficiency or paree load can be decreased without decrease in the efficiency of the press.

CASE I

Engineered/nip was applied in a paper mill in USA on the second press of a paper machine. The second press was double felted and had a 10 P&J covered roll over a stainless steel bare roll. When run at 210 kN/m (1200 pli) the felt life was an unacceptable 2 to 3 days. Replacing the 10 P&J cover with a 16 P&J significantly improved felt life to 25 days. This is seen in fig. 31 as point A on the upper curve (upper curve and left hand axis for pressure and lower curve and right hand axis for nip width). The mill wanted to improve extraction and decided to increasing the load-to 245 kN/m (1400 pli), seen as point B on the upper hard-soft curve. Although this increased nip pressure, there was very little improvement in moisture removal. It was analysed that the nip width was less and it was decided to by point C on the soft-soft upper curve. The loading was increased to 280 kN/m (1600 pli). This load was shown to have the same nip pressure as the press with a hard-soft combination loaded at 210 kN/m (1200 pli) The bottom curve shows the change in nip width relating to the press changes.

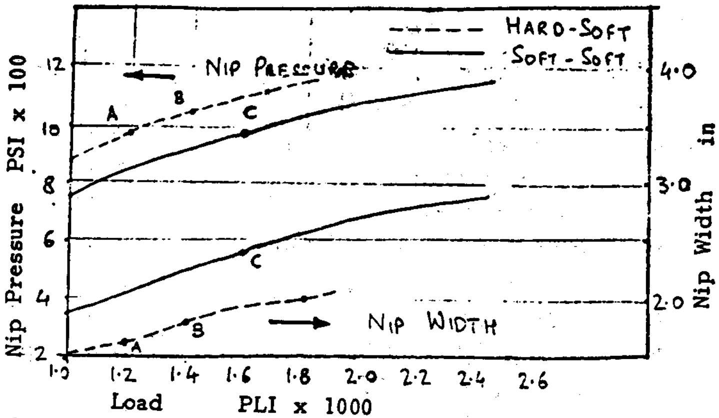


Fig. 31 Nip Pressure and Nip Width for Case I

The improvement in press was like having a rebuild—not only was there an increase in water removal, but the sheet density and Mullen were improved—so much so, the mill was able to shut down one refiner. Another plus—felt life was increased to 58 days.

CASE—II

For the Engineered Nip attention must be focussed on all the presses, not just on one press as is illustrated in this case. Here a paper mill in America rebuilt the third press for 245 kN/m (1400 pli) load with a 10 P&J top roll over a Microrok bottom. The rebuild gave them no improvement. In the analysis, seen in fig. 32, the first and second press were found to be inefficient.

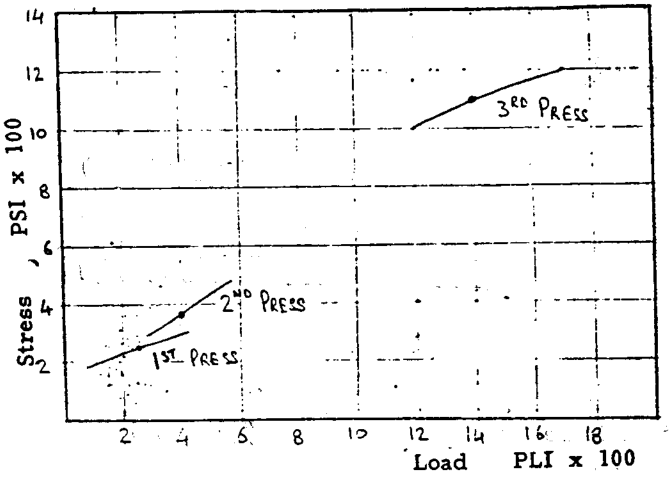


Fig. 32 Nip Pressures existing in the Machine, Case II

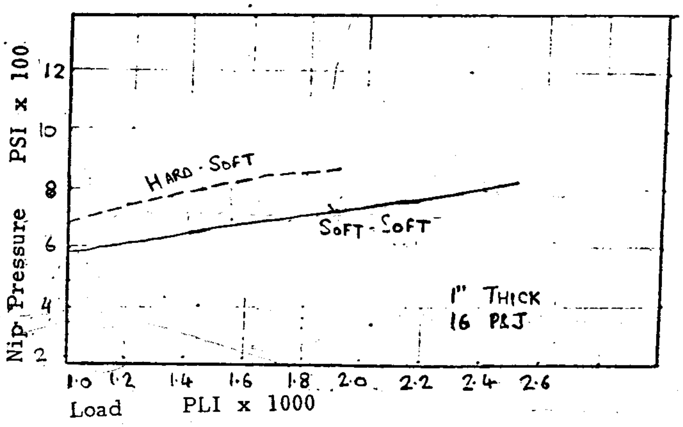


Fig. 33 Nip Pressure in Third Press after Modification, Case II

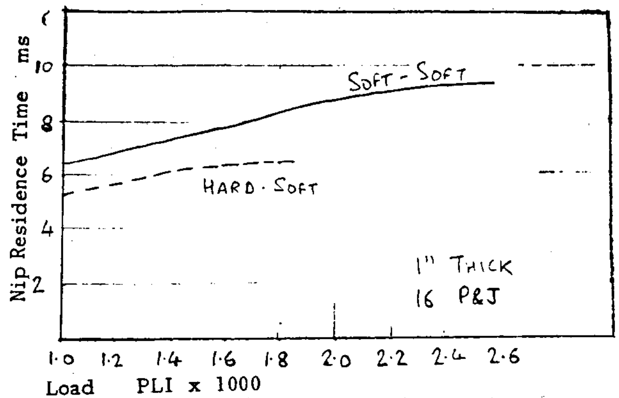
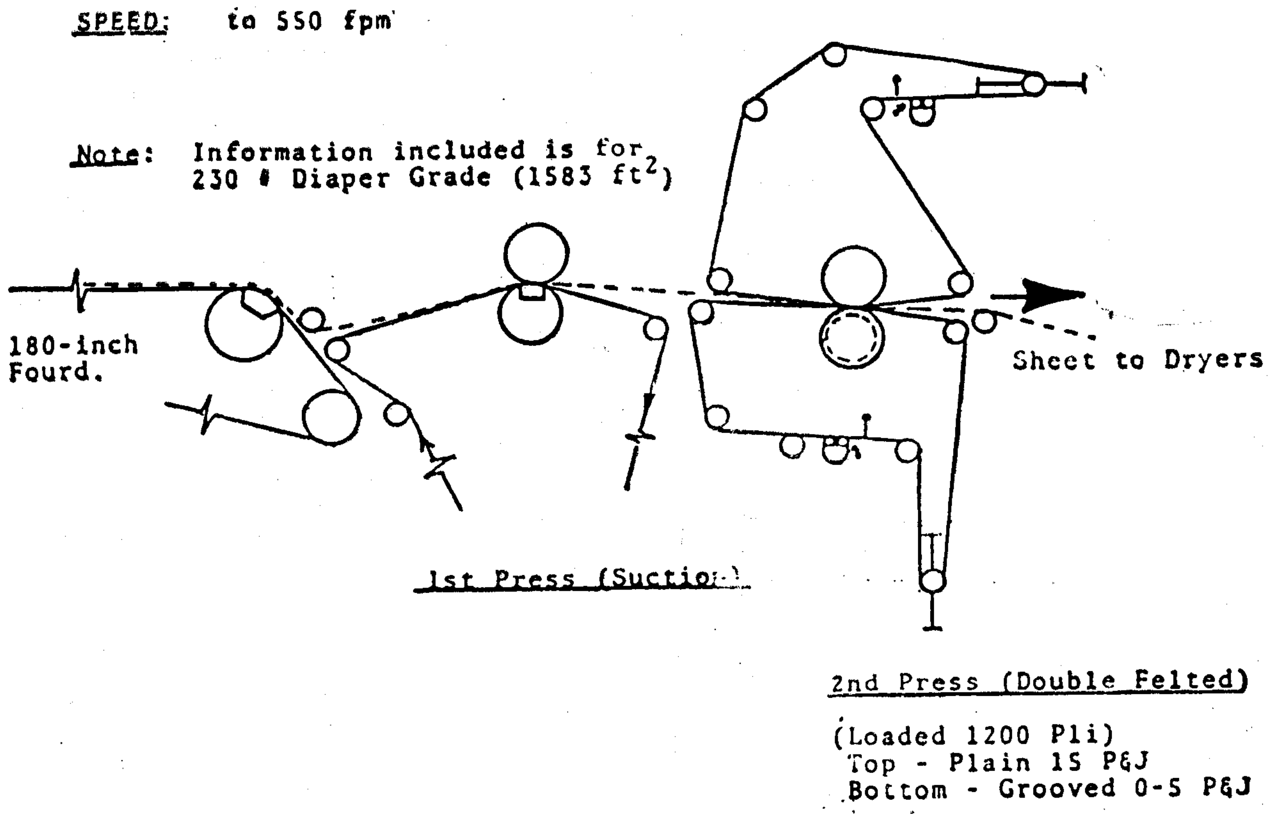


Fig. 34 Nip Residence Time in Third Press after Modification, Case II enhanced and felt life in the third press was increased. Case III

Each press had a 30 P&J Peeler covering on top of a 30 P&J suction roll and loads in the presses were 44 kN/m (250 pli) and 70 kN/m (400 pli) respectively. Sheet conditionin in the earlier presses is very important for the performance of the third press. The load in the second press was increased. The third press was replaced with both soft 16 P&J roll covers to increase the nip residence time in the press and to reduce the stress in the press. The effect of this on nip pressure is seen in fig. 33 and fig. 34 shows the effect on nip residence time. Due to these changes the sheet being made was enhanced and felt life in the third press was increased.

CASE III

Finally we would like to present a study where the customer wanted to increase the efficiency of the press and take out more water in the presses. The press condition before the nip way engineered is shown in Fig 35, which also shows the press performance. The machine has two presses, first a suction and double felted second with a grooved roll.



Existing Sheet Moistures:	**%Moisture**	**%Removal**
• Before 1st Press	73	—
• Before 2nd Press	64	9
• After 2nd Press	55	9

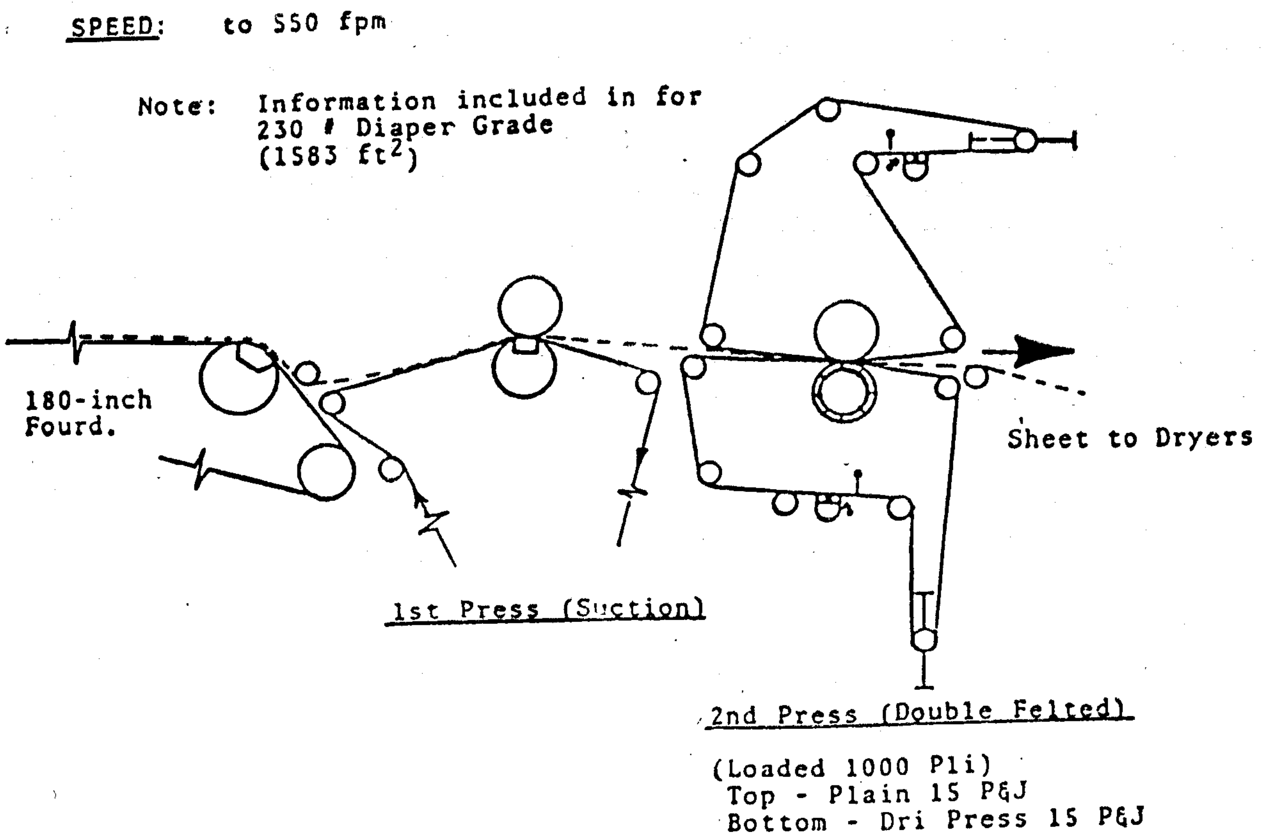
PRESS SECTION WATER REMOVAL :

Position	**"S H_2O/"A.D. Ueet**	**GPM**
1st Press	0.92	128
2nd Press	0.55	76.8

Fig. 35 Press Configuration and Performance Before

On analysis it was felt that the second press was not working as efficiently as it could. After analysis the grooved roll was replaced by a 15 P&J DriPress cover. The press performance after the rebuild is shown in fig. 36.

This helped to improve the moisture extraction by 20%, from 0.55 lbs of water per ‡AD sheet to 0.65 lbs of water per ‡‡lbs AD sheet. The sheet moisture decreased by 2%. The felt life went from 25 days to 55 days. Also the purge shower on the grooved press was closed down as it was not needed. The bulk and cross machine moisture profile were improved.



Sheet Moistures :	% Moisture	% Removed
. Before 1st Press	73	—
. Before 2nd Press	64	9
. After 2nd Press or . Before 3rd Press	53 (or less)	11

PRESS SECTION WATER REMOVAL :

Position	"'sH_2O/"A.D. Sheet	GPM
1st Press	0.92	128
2nd Press	0.65	90.8

Fig. 36 Case III Nip Parameters and Press Performance After

CONCLUSION

The mathematical model described gives adequate representation of that which is observed in the field. The Engineered Nip concept is a breakthrough in engineering principles regarding roll coverings in presses for improving efficiency in paper machines. Papermakers can have a high degree of confidence in the Engineered Nip to improve production and efficiency.

ACKNOWLEDGEMENTS

The authors would like to gratefully acknowledge the many contributions made by the Research Group of Stowe-woodward Co., Massachusetts, USA. Special thanks go to Joseph F. Cheatham, Ralph Hess and Arthur Kuehn. We would also like to acknowledge the contribution, help and encouragement received from our father S.V. Lathia.

REFERENCES

1. James P. McNamee, Heat Buildup in Rubber Covered Rolls, Tappi, Vol. 50, (6), Page 308, 1967
2. Joseph F. Cheatham and Jack Duggan, More Accurate Prediction of Heat Failure of Rubber Covered Rolls, Aug. 1976 issue of Pulp & Paper.
3. Joseph F. Cheatham, The Theoretical Prediction of the Steady-State Temperature Distribution in Roll Covers, Vol. 2, No. 2, 63-66, June 1976, Canadian Pulp & Paper Association at Montreal, P.Q. Jan. 27-30, 1976.
4. Internal Papers and Studies of Stowe-Woodward Co., Massachusetts, USA.